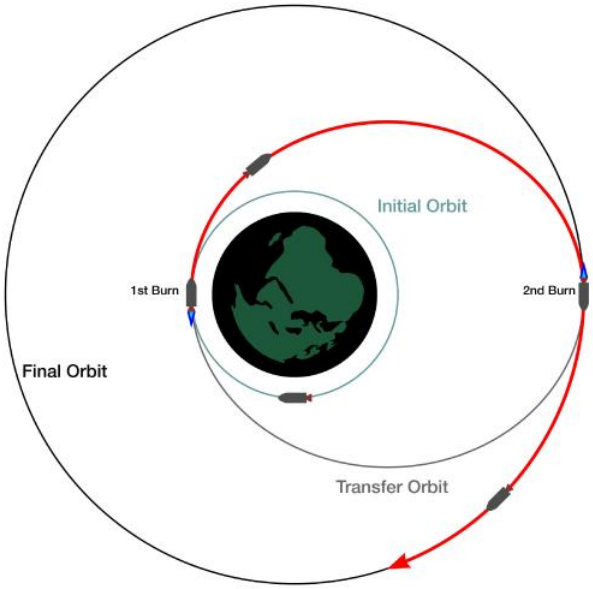
7.4: Exploring the Solar System

7.4.1 Hohman Transfer Orbits

You are in space, now what? Leaving Earth's gravity means the spacecraft is still in orbit around the Sun. Traveling to another planet is not as simple as flying in a straight line. The planets are all in motion and Sun's gravity will work to slow the probe down. The most fuel-efficient way to get to another planet would be to accelerate and put the spacecraft into a **Hohman transfer orbit.** A Hohman transfer orbit is an elliptical orbit that carries a craft from the orbital path of one planet to the orbital path of another. To get to Mars, the craft would have to accelerate by firing thrusters in the direction of Earth's orbital path. This increases the craft's velocity relative to the Sun and pushes it into a transfer orbit. Once in such a transfer orbit, the craft will orbit the Sun in a path that crosses both the orbit of the Earth and Mars. To get to Venus, the craft will accelerate against the Earth's revolution around the sun, slowing its orbital velocity relative to the Sun. This causes it to "fall" into a lower orbit that carries it into similar orbit that cross both the orbits of the Earth and Venus.

Of course, once your craft reaches Mars orbit, Mars might not be at the point in it orbit. If the craft arrives at Mars orbit and Mars is not there, it will continue on its transfer orbit and return to the Earth's orbit. To ensure that the planet is there to meet the problem when it arrives, the launch must be properly timed. The time when the planets make their closest approach, enabling the shortest transfer orbit is known as the **launch window**. For Mars, the launch window happens every 25 months while for Venus it happens every 19 months. Every launch window last for only a few weeks. Therefore, delays in launch could add years onto the mission and increase the cost by millions of dollars.



Hohmann Transfer orbits are used to efficiently transport a spacecraft to planets such as Mars or Venus.

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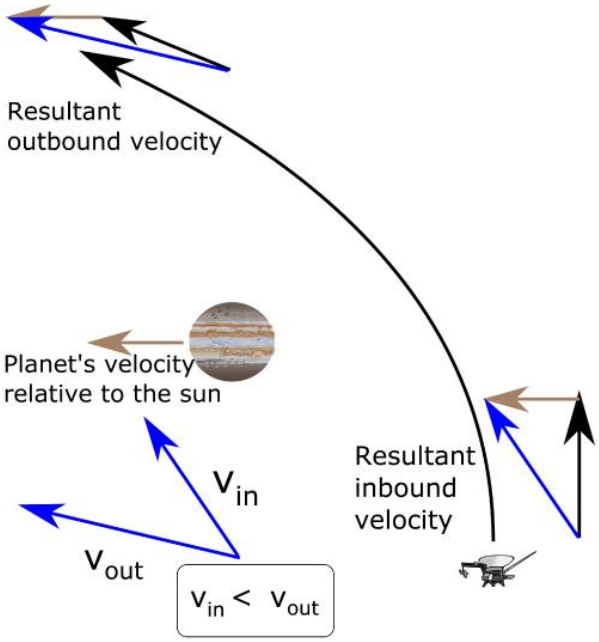
7.4.2 Gravity Assist

Another issue for traveling in the Solar System is that current propulsion technology limits us to getting out as far out as Jupiter or as far in as Venus. To get to Mercury or Saturn (and beyond), we need to use a **gravity assist** to get to speeds fast enough to counter the Sun's gravity. A gravity assist involves coming up behind a planet an "stealing" a bit of its angular momentum to gather speed. This creates a slingshot effective can fling a craft to higher velocities. Many missions to the outer solar system have involved multiple gravity assists, sometimes bouncing between Venus and the Earth, gathering speed with each pass, until the craft reaches a velocity high enough to make to the outer solar system. A planet's gravity can also be used to slow the craft down by passing in front of the planet. Planetary missions often use gravity deceleration to help put the probe into orbit around the planet.



Gravity assist maneuvers are used to reach the outer solar system by "borrowing" some momentum by making a close approach to another planet.

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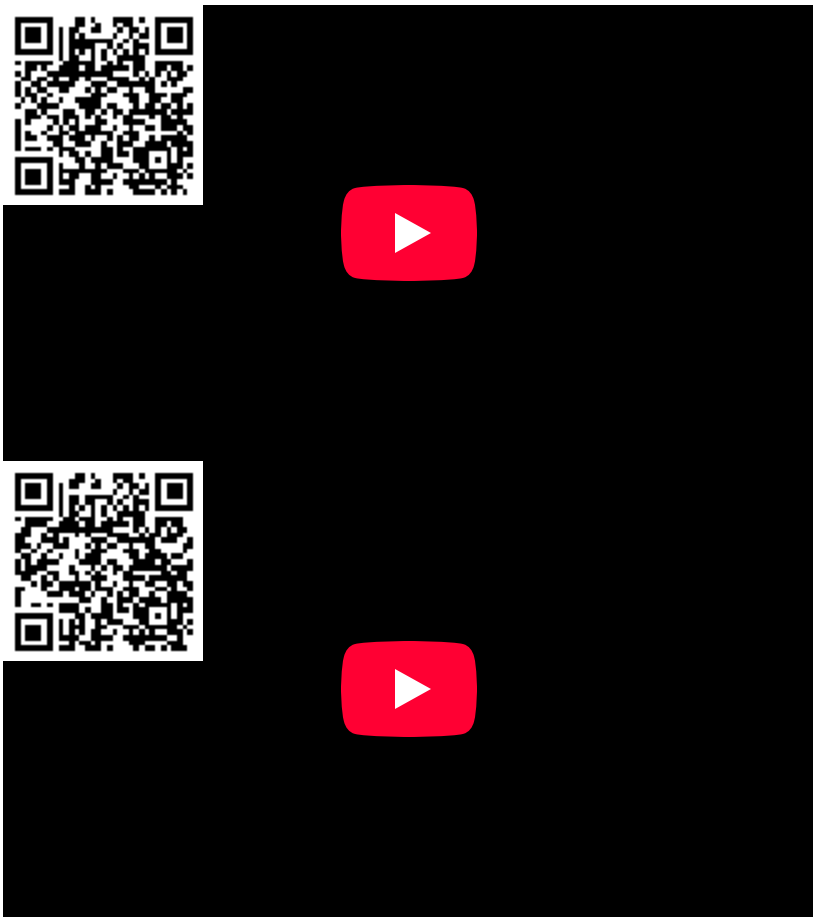

7.4.3 Types of Planetary Probes

NASA and other space agencies have launch different kinds of planetary probes. These include the following.

- **Flyby:** The probe makes a close approach to a body and then travels further on, not stopping. Many early planetary missions involved flybys, especially the Pioneer and Voyager missions to the outer solar system.
- **Orbiter:** The probe parks itself in orbit around an object for extended observations. Orbiters can be used to map the surface of a planet or take measures of its surface temperature, magnetosphere, and atmosphere.
- **Impactor:** A probe that is deliberately crashed into the surface of an object as it gathers data. Impactors are disposable probes which are meant only to collect data during its approach to the surface and cannot be used for extended missions. Several orbiters have been “retired” by crashing them onto the surface or burning up into the atmosphere of planets.
- **Atmospheric:** A probe designed to enter the atmosphere and take measurements, usually crashing on the surface or burning up in the atmosphere. The Soviet Union sent several atmospheric probes to Venus in the 60s and 70s. The Galileo probe also dropped an atmospheric problem into Jupiter’s atmosphere.
- **Lander:** A probe that makes a “soft” landing and starts collecting samples and/or data. Landers can operate for extended periods on the surface.
- **Rover**: A lander with wheels or trends that can move across the surface of a planet or moon. Unlike landers, which are limited to collecting samples in their immediate landing area, rovers can travel around the surface, collecting data and samples over a wider area.
